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Otolith Atlas of Freshwater Bony Fishes from Kashmir Waters in the Indian Himalayan Region

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ABSTRACT: This research represents the otolith belonging to fourteen species under five families of teleost fishes caught by using various fishing gears from different water bodies of Kashmir. The otoliths were removed carefully by making an incision in the cranium. The photographs of otoliths were taken in pairs using black background. This is the novel work on this subject for the fish species found in Kashmir valley.

Keywords: Otoliths, sagittae, exotic species, freshwater fish, gears, teleost.

INTRODUCTION

Otoliths are paired structures which are composed of organic matter and calcium carbonate crystals. The shape and size of otoliths vary among different species, population and also within each fish species. These variations are influenced by genetic and environmental factors during the growth and development of the fishes. These structures are located in the membraneous labyrinth in the inner ear and are responsible for sound detection and maintenance of balance (Lecomte-Finiger, 1999; Garcia *et al*., 2004; Payan *et al.*, 2004; Popper *et al*., 2005).

The formation of otolith involves rhythmic variations in the depositions and size of organic matrix fibre, which results in the formation of concentric layers of variable thickness (Morales-Nin, 2000). These layers alternate in opaque and hyaline layers, representing periods of fast and slow growth, respectively; in temperate zones a pair of these layers called, "annulus", and it is then used for age determination in years (Wright *et al*., 2002). Unlike other hard parts such as bones and sclaes, otoliths are quite resistant to digestion and act as important tool for prey classification in several dietary studies (Granadeiro and Silva 2002; Skeljo and Ferri 2012). Otoliths are left undigested in the stomach of predator and this has allowed to obtain precise information on the length, weight, age and quantity of fish prey individuals contributing to important knowledge for trophic ecology (Campana and Casselman 1993; Nielsen and Andersen 2001; Lowry, 2011).

The purpose of this work was to provide the photographic guide and information on the shape and size of otoliths of fishes found in Kashmir. This visual reference may serve as basis for various advanced studies related to fish otoliths. Since it is the novel work on the otoliths of the fishes found in Kashmir, there is no literature available to mention the drawbacks of previous work. The sole purpose of this work was to identify the shapes and sizes of ototliths of main fish species found in Kashmir.

MATERIALS AND METHODS

- A total of fourteen fish species were purchased from a local fisherman in dead condition.
- A total of twenty individuals per species were analyzed.
- Identification of fish samples was done by using standard taxonomical works of Day (1877); Kullander *et al.* (1999).
- All the fishes were weighed and measured before removal of otoliths.
- After the removal/extraction, the otoliths were washed with water and then dipped in 92% ethanol for 5 seconds to remove any cartilage.
- The otoliths were then kept in open air and left to dry before storing them.
- Afterwards, the otoliths were photographed in pairs against a black background using a Leica Stereo Macroscope connected to a computer with the image analysis program Leica Application Suite V3.7.

RESULTS AND DISCUSSION

In this work, otolith images of fishes found in Kashmir were determined for the first time. The otoliths of fourteen fish species belonging to five families were photographed. 5 of these species belong to the native fish community of Kashmir (*Schizopyge niger* Heckel, 1838, *Schizothoraxe socinus* Heckel, 1838, *Schizothorax curvifrons* Heckel, 1838, *Schizothorax plagiostomus* Heckel, 1838, *Schizothorax labiatus* Heckel, 1838). Of the fourteen species, five are exotic (*Cyprinus carpio var. communis* Linnaeus, 1758, *Cyprinus carpio var.*

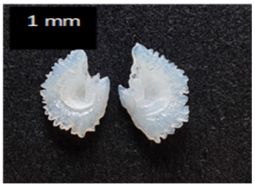
specularis Linnaeus, 1758, *Ctenopharyngodon idella* Valenciennes,1844, *Hypophthalmichthys molitrix* Valenciennes,1844 and *Oncorhynchus mykiss* Walbaum, 1792). The images of the otoliths are depicted in a table at the end of this section.

In this work it was shown that the sagittae otoliths of the fish species belonging to genus schizothorax have almost no morphological differences. It is in agreement with the observations of Torno (1976) who reported that species of the same genre may have similar otoliths that are almost non differentiable. In the families Cyprininae and Schizothoracinae, the shape of otolith is very similar (cuneiform) in almost all species. The differences in sizes is also insignificant. Correa and Vianna (1992-93) reported the existence of such common features within families, characteristics like common shape, location of the sulcus, form of the ostium and otolith tail. The otoliths belonging to families Nemacheilidae (*Triplophysa marmorata*) and Garrinae (*Crossocheilus diplochilus*) have similar morphology (discoidal and squared respectively) and size but are different from the other species. However, the otoliths of Rainbow Trout (*Oncorhynchus mykiss*) belonging to family Salmonidae showed prominent difference in shape and size from the rest of the species and was found to be lanceolated.

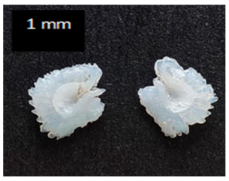
The fishes of the genus schizothorax form an important fishery resource of the valley. Among schizothoracids, *Schizothorax niger* is a valuable fish of Kashmir region, but is now, in stiff competition with other exotic fishes. It is reported that over half of the schizothorax's species have disappeared. The Dal Lake has some species while they are no longer found in other polluted water bodies of Kashmir. The introduction of exotic species and growing pollution has caused a sharp decline in the population of Schizothoracine fishes in Kashmir valley. Exotic fish species like Common Carp (*Cyprinus carpio*) and Trout (Oncorhynchus mykiss), which were introduced in 1965 and 1900, have been thriving at the cost of schizothorax.

OTOLITHS OF FISHES FOUND IN KASHMIR

Cyprinus carpio var. communis
(OL=5mm; OW=3mm)

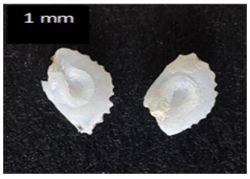


Cyprinus carpio var. specularis
(OL=5mm; OW=3mm)



Ctenopharyngodon idella
(OL=4mm; OW=3mm)

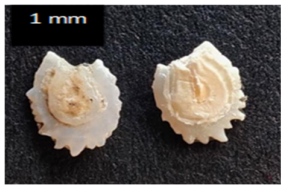
Hypophthalmichthyes molitrix
(OL=4mm; OW=3mm)



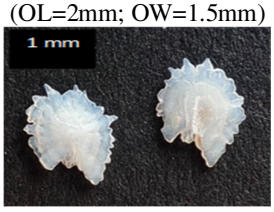
Bangana diplostoma
(OL=3mm, OW=2mm)

Puntius conchonius
(OL=2mm; OW=1.5mm)

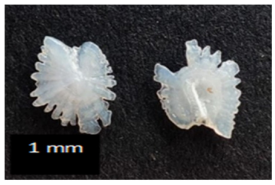
Crossocheilus diplochilus
(OL=1mm; OW=1mm)



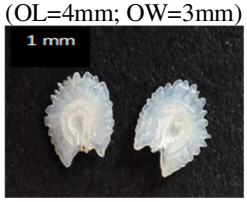
Schizothorax niger
(OL=4mm; OW=3mm)



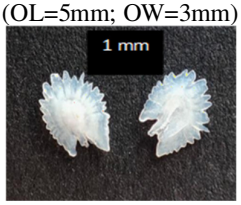
Schizothorax esocinus
(OL=5mm; OW=3mm)



Schizothorax curvifrons
(OL=4mm; OW=3mm)

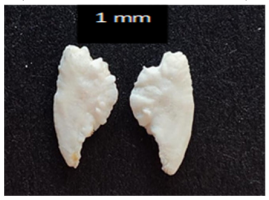


Schizothorax plagiostomus
(OL=5mm; OW=3mm)



Schizothorax labiatus
(OL=4mm, OW=3mm)

Triplophysa marmorata
(OL=1.5mm; OW=1mm)



Onchorynchus mykiss
(OL=6mm; OW=3mm)

CONCLUSIONS

In this research, otolith images of the fish species found in Kashmir were determined for the first time with an aim to provide a photographic guide of sagittae otoliths of the main fish species found in Kashmir. This atlas consists of photographic images of sagittae otoliths of fourteen species belonging to five families distributed in three orders.

FUTURE SCOPE

This work may be further be helpful in various studies such as age determination, species identification, size and weight estimates of preyed fish, migratory routes, etc.

Author Contributions. Nowsheen Mushtaq: Fish collection, experiment, measurements; Syed Talia Mushtaq: Conceptualized, investigation, helped in performing experiment; Taaduq Hussain Shah and Farooz Ahmad Bhat : Guide the experiment and manuscript; Syed Aalia Mushtaq : critically analysed the manuscript; Aziz-ul-Rehman: Helped in experiment and taking photographs of otoliths.

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Conflict of interest. None.

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